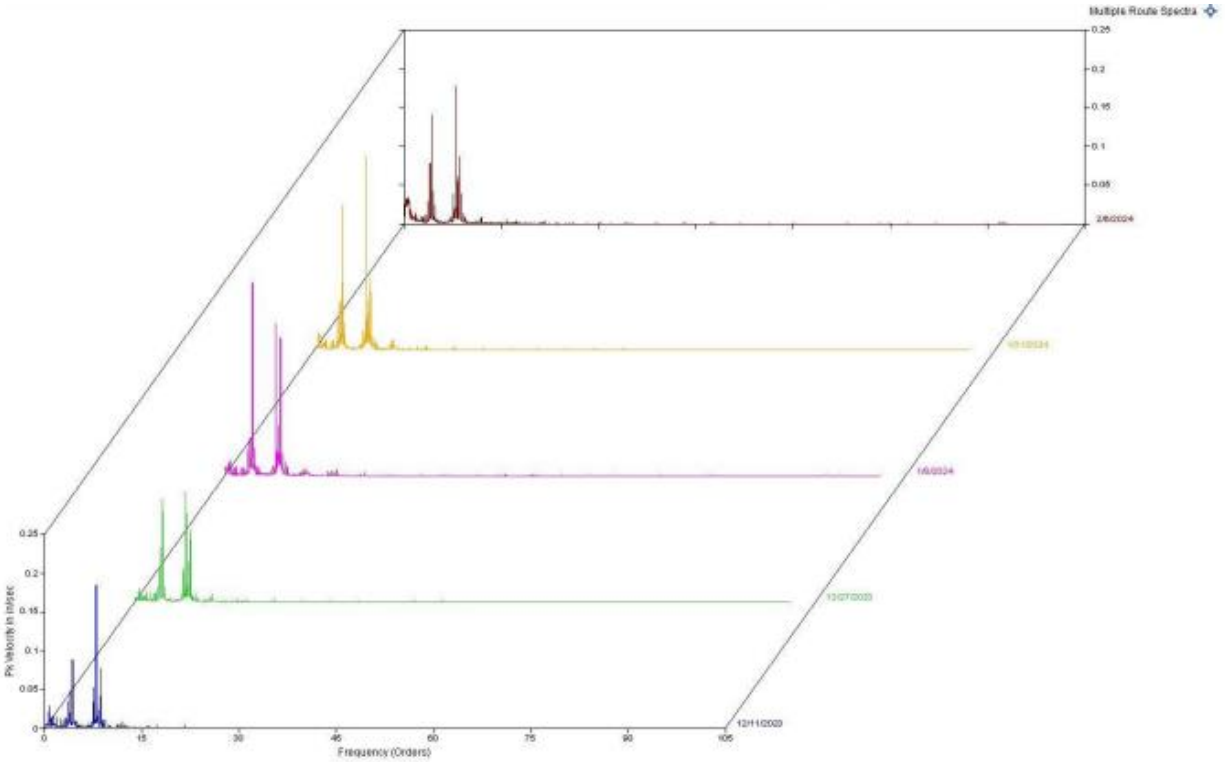
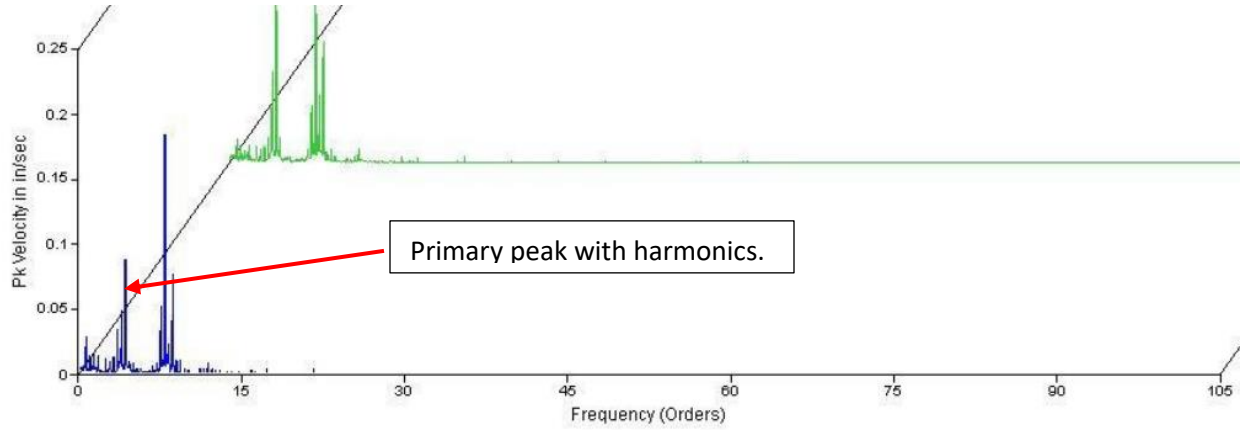
Knowing your Frequencies

A recent vibration report indicated an issue with the gearbox and recommends replacement. This was the plot that I was shown. An initial view of the plot would indicate the report would be correct and since the 2nd peak was elevated it would suggest gear misalignment.



However, when you blow this up so you can see the frequencies a little better as seen below there are a few things that popped out to me.



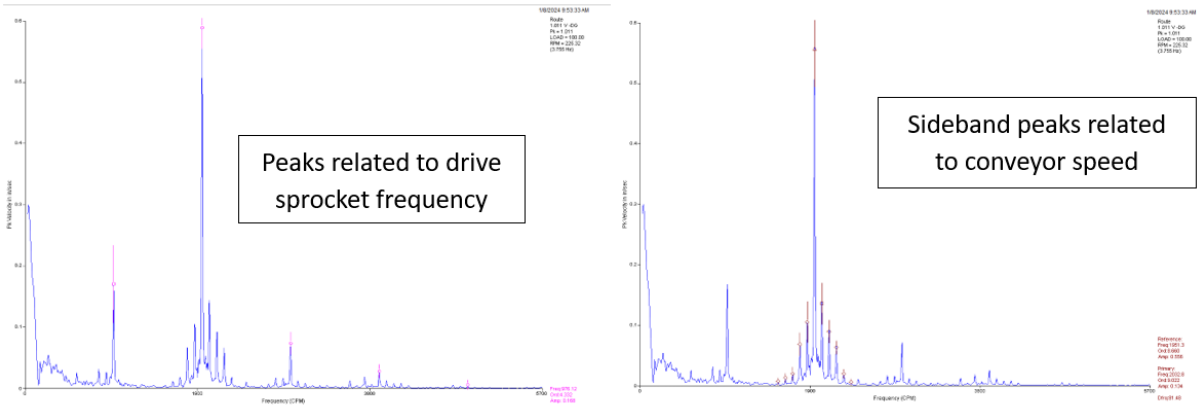
Looking at the frequency plot of the output data it seems to show the primary peak is around 4.3 Orders. So the second peak would suggest some type of misalignment because it was higher than the primary frequency. Basic vibration education tells us that is the correct pattern assumption. But gear mesh

frequencies are typically in the higher frequencies especially when looking at the output data of a gearbox.

When we discussed this plot what I found out was the default speed for this location was set at 225 rpm thus the 4.3 order frequency when in fact it was running at 57.? rpm. If we do the math based on the indicated orders from the software it came out to 4.332 orders times default speed this equals 974.7 cpm. As we continued the discussion I was told the side band frequencies around these peaks were spaced at 80 cpm.

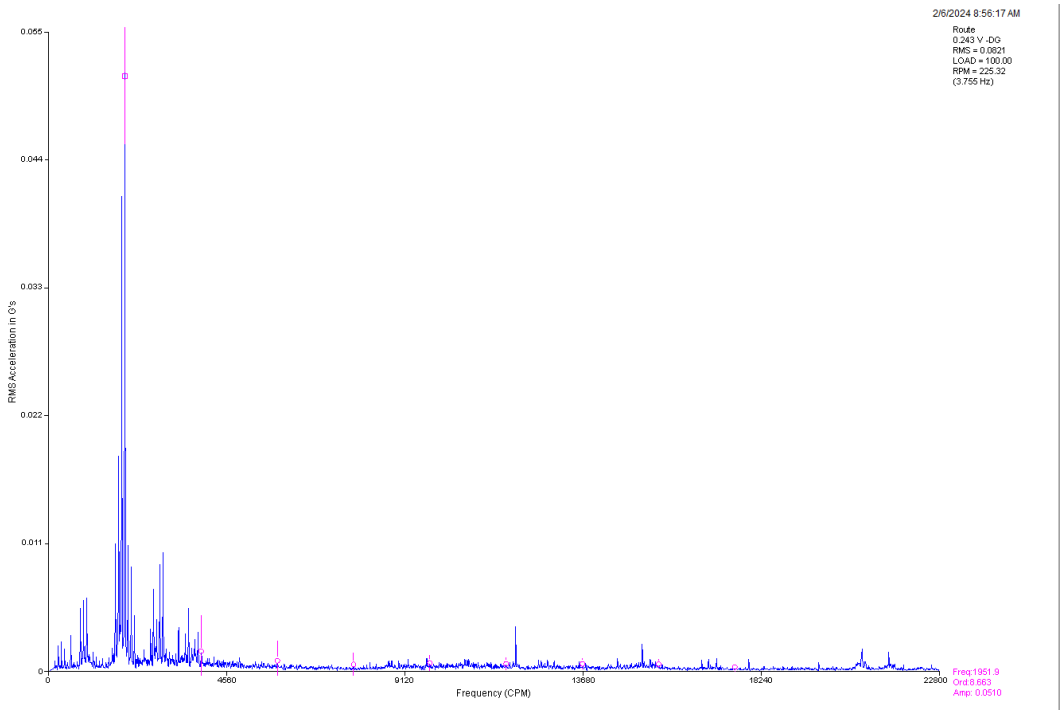
As the primary peak was identified in CPM the conversation using the correct output speed data it came out to 17 time the actual running speed at the output location. The side bands that were spaced around these primary peaks were all equally spaced at 80 cpm which again suggested a possible internal shaft speed but not likely with an output speed of 57 cpm. You will also need to consider the resolution of the spectrum so the 80 cpm peaks could be a few cpm above or below this frequency.

What was being shown was the 17 times the output speed with harmonics was not a gear issue but the drive sprocket frequency of this conveyor. The elevated 2nd harmonic suggests sprocket misalignment. The most recent data also shows a total of 5 harmonics of this frequency all surrounded by the 80 cpm side bands. The harmonics also suggest a possible loose-fitting sprocket since the number of harmonics were increasing. The following plot shows the primary peak with the harmonics indicated.



As I did a little more research on the conveyor what was also found was the conveyor speed was 79 feet per minute. To me this will explain the side band frequencies we were seeing around the second peak.

This is where the research of the machine and its components comes into play. It takes time to gather this information, but it pays high dividends in the end and helps you make correct recommendations. However just because some of these things line up it is still worth screening the data against known frequencies and vibration rules. When we go through all the possible frequencies in the gearbox we will find that the intermediate shaft bearing TMK 6576C/6535 has an BPFO of 1955 cpm when the input speed of the gearbox is 1790 cpm. So, if we look at the 2nd primary peak of the spectrum which is 1952 cpm we could argue that is the bearing outer race frequency so there is a bearing defect in the gearbox. However, if we look at the spectrum in acceleration below then you would expect to see harmonics of this frequency in the upper frequencies. As we are taught in vibration classes the bearing defect begins in the upper frequencies then as they get worse the harmonics will progress into the lower frequencies. This rule is not supported in the data we must work with.



Now let us go back to the original call that we have a developing gear wear issue in the gearbox based on the harmonics and the side bands. The pattern would support this call. We first need to run the numbers for this issue to see if it fits the rules and the calculations we are taught in our vibration classes. All the gearbox frequencies are shown in the following table.

Bearing Freq CPM			1790	1790	1790	1790		
2nd Shaft								
2nd Shaft RPM	237.6	Gear tooth count ring gear	113	Pinion Gear tooth count	14		Gear Mesh Frequency	3327
4A1	TIM 6576C / 6535	4A2	TIM 6576 / 6536B				2X GMF	6653
Bearings		# Balls / Rollers	FTF	BSF	BPFO	BPFI	3X GMF	9980
Bearing freq ORDERS	TIM 6576C / 6535	19	0.433	3.571	8.228	10.772	FTFI Inner 0.433 FTFO Outer 0.567	
Bearing Freq CPM			102.9	848.5	1955.1	2559.5		
Bearing freq ORDERS	TIM 6576 / 6536	19	0.433	3.571	8.228	10.772	FTFI Inner 0.433 FTFO Outer 0.567	
Bearing Freq CPM			102.9	848.5	1955.1	2559.5		
Bearing freq ORDERS								
Bearing Freq CPM			237.61	237.61	237.61	237.61		
Bearing freq ORDERS								
Bearing Freq CPM			237.61	237.61	237.61	237.61		
Output Shaft								
Output Shaft RPM	57.4	Gear tooth count ring gear	58				Gear Mesh Frequency	3327
5A1	TIM 938 / 932	5A2	TIM HH221449 / HH221410B				2X GMF	6653
Bearings		# Balls / Rollers	FTF	BSF	BPFO	BPFI	3X GMF	9980
Bearing freq ORDERS	TIM HH221449 / HH221410B	17	0.417	2.896	7.097	9.903	FTFI Inner 0.417 FTFO Outer 0.583	
Bearing Freq CPM			23.9	166.1	407.0	568.0		
Bearing freq ORDERS	TIM 938 / 932	18	0.427	3.276	7.679	10.321	FTFI Inner 0.427 FTFO Outer 0.573	
Bearing Freq CPM			24.5	187.9	440.4	592.0		

The one for the bearing is circled and then the current gear mesh frequency is also circled with the harmonics. As we look at the vibration data we have the gear mesh frequency is not showing up and neither are the harmonics. Then again when we look at the listed bearing frequencies the BPFO is close to the 2nd harmonic of drive sprocket frequency but no other harmonic of that frequencies in the upper range of the spectrum. Another thing to look for is the side band frequencies of 80 cpm. That frequency

is not showing up in any of the known frequencies in the gearbox. If the original peak was related to gear wear the rules we are taught is the side bands are related to the shaft speed of the one of the gears. There is a rule that tells us there can be a peak in the lower frequencies between the gear shaft speeds and the 1st gear mesh frequency known as the Gear Natural Frequency and that will have sidebands spaced at the speed of the shaft with the bad gear. In this case we do not have any peaks shown at 3327 cpm or its harmonics and we have no side band peaks spaced at 57 cpm the output shaft speed of 237 cpm the intermediate shaft speed. Therefor based on the data we must work with that issue can also be ruled out.

Based on the knowledge of what is in the gearbox and the known frequencies they should generate and the rules we are taught in our vibration education the only frequencies that match up are the drive sprocket frequency of 974 cpm and harmonics of that frequency. The known conveyor paddle/chain frequency of 79 feet per minute.

In the end based on the frequencies seen in the vibration data and the knowledge we have from our research would be:

Check the sprocket alignment, wear, run out and drive chain tension. Inspect the internal drag chain for proper tension and paddle wear. Make the needed adjustments or repairs.